NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

NUTRIENT MANAGEMENT

(Acre)
CODE 590

DEFINITION

Managing the amount, source, form, placement and timing of applications of plant nutrients and amendments.

PURPOSES

This practice may be applied as part of a conservation management system to support one or more of the following:

- To budget and supply nutrients for plant production.
- To properly utilize manure or organic by-products as a plant nutrient.
- To minimize nutrient loss to surface and groundwater.
- To maintain or improve soil quality.
- To minimize excess nutrient concentration in the soil.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all land where plant nutrient and amendments are applied. This standard does not apply to municipal and industrial by-products or waste.

CRITERIA

Laws, Regulations, and Policies

Nutrient management plans (NMP) shall comply with all applicable federal and local regulations.

Plans for nutrient management shall be developed in accordance with policy requirements of the NRCS General Manual Title 450, Part 401.03 (Technical Guides, Policy and Responsibilities), and Title 190, Part 402 (Ecological Sciences, Nutrient Management, Policy); technical requirements of the NRCS Field Office Technical Guide (FOTG), procedures contained in the National Planning Procedures Handbook (NPPH), and the NRCS National Agronomy Manual (NAM), Section 503.

Plan Certification

Natural Resources Conservation Service (NRCS) employees in the Caribbean Area whom review or approve plans or any components for nutrient management shall be certified through Caribbean Area Conservation Planners and Specialist Certification Process. Certified Conservation Planner shall review or approve nutrient management practices and land treatment practices. Certified Specialist shall review or approve manure and waste handling and storage. Any other person with NRCS job approval can do all other applications of nutrients and amendments.

Nutrient Management Plans (NMP)

A plan for nutrient management may be stand alone, but when it is part of a more comprehensive conservation plan it shall recognize other requirements of the conservation plan and shall be compatible with those other requirements.

A review of the NMP shall be performed, as a minimum, every five years or when any management practices change drastically the overall performance. An annual review is encouraged. A Certified Conservation Nutrient Planner or Certified Nutrient Specialist shall approve all revisions.

Plans for nutrient management shall specify the form, source, amount, timing and method of

application of nutrients on each field to achieve realistic producing goals, while minimizing nitrogen and/or phosphorus movement to surface and/or ground waters.

Site Assessment

All field, site, or farm using organic or inorganic fertilizer shall be evaluated for nutrient impact in ecosystem.

Site assessment may include, but no limited to:

1. Topography and land form.
2. Soil infiltration and erosion characteristics.
3. Depth to water table.
4. Geology maps.
5. Ground and surface water physical and hydraulic characteristics.
6. Climate data, including rainfall intensity precipitation.
7. Distance to water body.
8. Endangered species maps.
9. Puerto Rico and United States Virgin Islands Unified Watershed Assessment and Restoration Priorities.

The User Guide for the Interpretation of Soil Fertility, in Appendix 1, based on Soil Fertility Capability Classification is recommended to make soil interpretation for fertilizer manage-ment. This system evaluates criteria relevant to soil-fertilizers interaction.

The Caribbean Area Phosphorus Index, shall be used to assess the potential risk of phosphorus movement into water from sites receiving animal manure, poultry litter, compost or other organic by-products.

Yield Goals

Realistic yield goals shall be established based on soil productivity information, historical yield data, climatic conditions, level of management and/or local research on similar soil, cropping systems, and soil and manure/organic by-product tests. For new crops or varieties, industry yield recommendations may be used until documented information is available.

The Agricultural Waste Management Field Handbook, Chapter 6, Role of Plants and Table 1 Tropical Crop Nutrient Uptake Values provides average crop yields for most tropical plants grown in the Caribbean Area.

Nutrient Budget

A nutrient budget for nitrogen, phosphorus, and potassium shall be developed that considers all potential sources of nutrients including, but not limited to animal manure and organic by-products, waste water, commercial fertilizer, crop residues, legume credits, and irrigation water. Nutrient Budget Worksheet, Exhibit 590-1 might be used as a guide.

Nutrient budget may be prepared using:

1. University of Puerto Rico, Agricultural Experiment Station (UPR, AES) crop production technical guide and others fertilizers guides for each correspondent crop.

2. Soil, plant tissue, and manure test values.

3. Nutrient content credit for organic sources such as legumes or green manure crops, crop residues, compost, poultry litter, and manure from poultry, dairy, hog, horses, and rabbits.

4. Table 1 - Crop uptake and general nutrient recommendations for crop grown in the Caribbean Area. Crop uptake and nutrient recommendation are not absolute, and yields may vary with climate, soil fertility and quality, and management. The Conservation planner must make an agronomic judgment while preparing nutrient management plan.

5. Table 2 - Nutrient Interpretation Guide for Soil Test Analysis.

6. Tables, values, and guides contained in the NRCS, Agricultural Waste Manage-ment Field Handbook, Chapter 4, Agricultural Waste Characteristic.

Water Budget

A water budget is suggested in irrigated land or any other sensitive zones where runoff or deep percolation may occur.

Water budget may include:

1. Average rainfall distribution curve and irrigation water input.

2. Average potential for deep percolation.

3. Average potential for runoff.

4. Evapotranspiration curve for crop for a specific or an average over a several year period.

5. Evaporation during the non-growing period.

6. Soil moisture content over specific or extended time period.

The Irrigation Water Management (Practice Standard 449) should be a component of a nutrient management plan in irrigated land.

Soil Erosion and Runoff Control

Erosion, runoff, and water management controls practices shall be installed, as needed, on fields that receive nutrients. These practices will be applied as needed to meet quality criteria of Section III of the FOTG. Table 3 - Summary of Best Management Practices Conservation Effects on Nutrient Management can be used to determine the physical effects that management practices have on major resource concerns.

For inorganic NMP, soil erosion rates should be controlled to the level stated in the conservation plan. Conservation plan may be resource management system or a progressive planning system.

For organic NMP soil erosion should be controlled to the soil loss tolerance.

Conservation buffers such as Filter Strip (Practice Standard 393), Riparian Forest Buffer (Practice Standard 391), Grassed Waterway (Practice Standard 412), and Field Border (Practice Standard 386) shall be established or maintained along field edges in environmentally high risk areas, such as fields adjacent to streams, pond, lakes or sink hole, to reduce nutrients transported with sediment and runoff water.

Soil Sampling and Testing

Nutrient planning shall be based on current soil tests results developed in accordance with the University of Puerto Rico, Mayaguez Campus, College of Agricultural Sciences guidance and the University of the Virgin Islands, Cooperative Extension Service. Current soil tests are those that are less than five years old.

Soil samples shall be collected and prepared according to the University of Puerto Rico, Mayaguez Campus, College of Agricultural Sciences guidance. The publication “Muestreo de Suelos” issued by Agricultural Extension Service of the University of Puerto Rico can be used as a guide.

Laboratories that are accepted in one or more of the following programs shall perform soil test analyses:

- State Certified Programs.

- The North American Proficiency Testing Program (Soil Science of America).

Soil testing shall include analysis for any nutrients for which specific information is needed to develop the nutrient plan. Request analyses pertinent to monitoring or amending the annual nutrient budget, e.g. pH, soil organic matter, total nitrogen, extractable phosphorus, calcium, magnesium and potassium.

Soil sample should be taken from the surface layer (0-6 inches) of the profile.

Plant Tissue Sampling and Testing

Tissue sampling and testing, where used, shall be done in accordance with the University of Puerto Rico, Mayaguez Campus, College of Agricultural Sciences guidance, and the University of the Virgin Islands, Cooperative Extension Service standards or recommendations.

Manure Sampling and Testing

Manure sampling and testing, where used, shall be done in accordance with the University of Puerto Rico, Mayaguez Campus, College of Agricultural Sciences guidance and the University of the Virgin Islands, Cooperative Extension Service standards or recommendations.

Manure sample shall represent the average composition of the material that will be applied in the field. The sampling methods vary according to the type of manure.

Nutrient Application Rates

Nutrient application rates shall be based on “Conjuntos Tecnológico” (crop technological guide) issued by the Agricultural Experiment Station of the University of Puerto Rico and the University of the Virgin Islands, Cooperative Extension Service recommendations that consider current soil test results, realistic yield goals, and management capabilities. If the Land Grant University does not provide specific recommendations, application shall be based on realistic yield goals and associated plant nutrient uptake rates.

Table 2 - Nutrient Interpretation Guide for Soil Test Analysis can be used to determine if the nutrient level is above agronomic requirement of the crop.

The planned rates of nutrient application, as documented in the nutrient budget, shall be determined based on the following guidance.

- **Nitrogen Application** - Planned nitrogen application rates shall match the recommended rates as closely as possible, except when manure or other organic by-products are a source of nutrients, see "Additional Criteria" below. The application rate will be determined for each crop in the rotation.

- **Phosphorus Application** - Planned P application rates shall match the recommended rates as closely as possible, except when manure or other organic by-products are a source of nutrients. The application rate will be determined for a single crop or for the crop rotation. Soil deficient in available P (highly weathered and alkaline soils) may require higher application to sustain crop production. When manure or other organic by-products are a source of nutrients, see "Additional Criteria" below.

- **Potassium Application** - Excess potassium shall not be applied in situations in which it causes unacceptable nutrient imbalances in crops or forages. When forage quality is an issue associated with excess potassium application, state standards shall be used to set forage quality guidelines.

- **Other Plant Nutrients** - The planned rates of application of other nutrients shall be consistent with the University of Puerto Rico, Mayaguez Campus, College of Agricultural Sciences guidance, and the University of the Virgin Islands, Cooperative Extension Service.

- **Starter Fertilizers** - Starter fertilizers containing nitrogen, phosphorus and potassium may be applied in accordance with the University of Puerto Rico, Mayaguez Campus, College of Agricultural Sciences guidance, and the University of the Virgin Islands, Cooperative Extension Service recommendations. When starter fertilizers are used, they shall be included in the nutrient budget.

- **Soil amendments** - can be applied, as needed, to adjust soil pH the specific range of the crop for optimum availability and utilization of nutrients.

Nutrient Application Timing

Timing of nutrient application shall correspond as closely as possible with plant nutrient uptake characteristics, while considering cropping system limitations, weather and climatic conditions, and field accessibility.

Nutrient Application Methods

Nutrients shall not be applied to saturated soil if the potential risk for runoff exists.

Nutrient applications in irrigated land shall be in accordance with the requirements of Irrigation Water Management (Practice Standard 449). The irrigation systems shall be designed in accordance with Practice Standard 442, Irrigation System, Sprinkler and Irrigation System, and Micro-irrigation Practice Standard 441.

Manure shall be applied to the utilization area in amounts and at a time consistent with the manure management plan and Waste Utilization, Practice Standard 633. Sprinkler application of liquid manure shall be designed in accordance with Practice Standard 442, Irrigation System, Sprinkler.

The nutrient content and composition of wastewater shall be considered in the design of Filter Strip, Practice Standard 393A.

Additional Criteria Applicable to Manure or Organic by-Products Applied as a Nutrient

Manure Generation and Composition

Manure production data and nutrient content values of manure and organic by-products shall be determined using standard values contained in NRCS, AWFMH, Chapter 4 Agricultural Waste Characteristics, if on farm site specific data and laboratory analysis are not available.

Nutrient Application Rates

The application rate (in/hr) for material applied through irrigation shall not exceed the soil intake/infiltration rate. The total application shall not exceed the water holding capacity of the soil.

Application rate must be adjusted to match the soil intake so that it prevents deep percolation or runoff.

The extremely high mineralization rate in our tropical condition may increase nutrient availability and losses if management practices are not adequate for nutrient utilization.

Land application rates should be based on the nutrient requirements of the crop. Manure can be applied at rate to supply any of the recommended nutrients

The planned rates of nitrogen and phosphorus application documented in the plan shall be determined based on the following guidance:

- **Nitrogen Application** - When the plan is applied using a phosphorus-based budget, manure or other organic by-products shall be applied at rates consistent with the phosphorus crop uptake. In such situations, an additional nitrogen application may be required to supply the recom-mended amounts of nitrogen.

  The phosphorus content in the animal manure shall be accounted for in the nitrogen-based application. The application rate based on nitrogen crop uptake may result in application of phosphorus above crop needs. In this case, apply manure in P deficient soils, soils with high sorption potential, and cropland with high P uptake or increase acreage requirement to reduce the amount of P applied per unit of land.

  Manure or other organic by-products may be applied on legumes at rates equal to the estimated removal of nitrogen in harvested plant biomass.

- **Phosphorus Application** - When manure or other organic by-products are used, the planned rates of phosphorus application shall be consistent with the Phosphorus Index (PI) Rating. (Nitrogen based manure application on Low or Medium Risk Sites while phosphorus based on High and Very High Risk Sites).

Field Risk Assessment

When animal manure or other organic by-products are applied, a field-specific assess-

ment of the potential for phosphorus transport shall be completed. This assessment may be done using the Phosphorus Index or other recognized assessment tool. In such cases, plans shall include:

- A record of the assessment rating for each field or sub-field.
- Information about conservation practices and management activities that can reduce the potential for phosphorus movement from the site.

When such assessments are done the results of the assessment and recommendations shall be discussed with the producer during the development of the plan.

Additional Criteria to Protect Water Quality

In environmentally sensitive areas (Highly Erodible Lands, flood plains, karstic formation, soils with excessive permeability, well head protection areas or nutrient restricted areas) an assessment shall be completed of the potential for nitrogen and/or phosphorus transport from the field. Special consideration should be taken when a soluble nutrient such as nitrogen is applied. Hydrologic groups, depth to water table, climatic data, and groundwater physical and hydraulic characteristics can be used as a guide to evaluate leaching potential. Phosphorus pollution potential shall be asses-sed using the Caribbean Area Phosphorus Index.

Exclude animals from water bodies or any other sensitive areas to control manure deposition. Refer to practice Use Exclusion (472)

Plans developed to minimize agricultural nonpoint source pollution of surface or ground water resources shall include practices and/or management activities that can reduce the risk of nitrogen or phosphorus movement from the field. The results of these assessments and recommendations shall be discussed with the producer and included in the plan.

Additional Criteria to Soil Quality

Nutrients shall be applied in such a manner as not to degrade the soil structure, chemical properties, or biological condition. Use of nutrient sources with high salt content will be minimized unless provisions are used to leach salts below the crop root zone.

Nutrients shall not be applied to flooded or saturated soils when the potential for soil compaction is high.

Adequate storage facilities shall be available to allow application on a timely basis.

Testing for nutrient content will be conducted periodically to adjust nutrient application rates.

CONSIDERATIONS

Nutrient Management Plans

- Consider annual reviews to determine if changes in the nutrient budget are desirable (or needed) for the next planned crop.
- Consider using soil test information no older than one year when developing new plans, particularly if animal manure is to be a nutrient source.
- Consider ways to modify the chemistry of animal manure, including modification of the animal's diet to reduce the manure nutrient content, to enhance the producer's ability to manage manure effectively.
- Realistic yield goals should be set based on soil type, available moisture, historical yield data, climatic conditions, and fertilizer cost versus returns.
- Use of practices such as double cropping or planting cover crops can be used to take up excess plant nutrients and help prevent their movement out of the root zone.
- Use of appropriate application methods and fertilizer formulations may minimize nutrient losses.

Site Assessment

- Consider the most appropriate sampling technique and test method that best represent the producers farming system.
- On sites on which there are special environmental concerns, consider other sampling techniques.
- Consider all eligible cultural resources.
- Consider the potential to affect wildlife habitat.
- Consider the effect in soil characteristics of previous fertility management practices when the Soil Fertility Capability Classification is used to make fertility interpretations.

Nutrient Application Rates, Methods and Timing

- The nutrient budget for the proposed crop(s) including an estimate of residual amounts present in the soil and in residues of previous crops, along with any organic waste additions, can show how much fertilizer needs to be applied, if any.
- Consider application methods and timing that reduce the risk of nutrients being transported to ground and surface waters, or into the atmosphere. Suggestions include:

1. Split applications of nitrogen to provide nutrients at the times of maximum crop uptake.
2. Band or place applications of phosphorus near the seed row.
3. Applying nutrient materials uniformly to application areas or as prescribed by precision agricultural techniques.
4. Immediate incorporation of land applied manure or organic by-products.
5. Incorporate broadcast fertilizer on cultivated crops.
6. Delaying field application of animal manure or other organic by-products if precipitation capable of producing runoff and erosion is forecast by the time of the planned application.

- The form of fertilizer and its timing, placement, and method of application can often be manipulated to conform to seasonal variations in nutrient removal, reduce soil fixation, and avoid excessive soil solution nutrient concentration that could leach out of the root zone when heavy rains cause the soil moisture-holding capacity to be exceeded.
- Proper calibration and use of equipment will reduce undesirable concentrations.

Conservation Buffer

- Consider additional practices such as Conservation Cover (327), Grassed Waterway (412), Contour Buffer Strips (332), Filter Strips (393), Irrigation Water Management (449), Riparian Forest Buffer (391A), Conservation Crop Rotation (328), Cover and Green Manure (340), and Residue Management (329A, 329B, or 329C, and 344) to improve soil nutrient and water storage, infiltration, aeration, tilth, diversity of soil organisms and to protect or improve water quality.
- Consider cover crops whenever possible to utilize and recycle residual nitrogen.
- Consider a minimum application setback distance from environmentally sensitive areas, such as sinkholes, wells, gullies, ditches, surface inlets or rapidly permeable soil areas.

Air Quality

- Consider the potential problems from odors associated with the land application of animal manure, especially when applied near or upwind of residences.
- Consider nitrogen volatilization loss associated with the land application of animal manure. Volatilization losses can become significant, if manure is not immediately incorporated into the soil after application.

Water Quality

- Consider the effects of the seasonal water budget on nutrient balance and on potential loss from the surface or ground water. These effects will be the basis for developing the nutrient management plan.

- Evaluate water quality standards and designated use limitations that exist locally or statewide. In high water table soils, water table management will affect the availability and movement of nutrients. The water table level should be maintained with as minimum variation as possible.

Soil Quality

- Avoiding excessive or luxury levels of N, P, and K in the soil will help reduce the potential for induced deficiencies of secondary nutrients and micronutrients.

- Consider phosphorus build up potential on nitrogen based application.

- Maintain proper soil pH for the crop to be grown for optimum utilization of applied nutrients, while preventing toxicity from other accumulated elements such as phosphorus, manganese or copper. Strongly acid pH must be adjusted to levels higher than 5.5 to avoid aluminum and manganese toxicity and low availability of phosphorus.

- Maintenance of good soil tilth will help make plant nutrient availability more efficient, reducing the need for additional fertilizer to compensate for poor root development and near surface drought conditions caused by poor soil structure and low organic matter level.

- Move fertilizer loading and transfer areas around to prevent heavy concentration of nutrients in these areas.

PLANS AND SPECIFICATIONS

Plans and specifications shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose(s), using nutrients to achieve production goals and to prevent or minimize water quality impairment.

The following components shall be included in the nutrient management plan:

1. Aerial photograph or map and a soil map of the site.
2. Current and/or planned plant production sequence or crop rotation.
3. Results of soil, plant, water, manure or organic by-product sample analyses.
4. Realistic yields goals for the crops in the rotation.
5. Quantification of all nutrient sources.
6. Recommended nutrient rates, timing, form, and method of application and incorporation.
7. Location of designated sensitive areas or resources and the associated, nutrient management restriction.
8. Guidance for implementation, operation, maintenance, and recordkeeping.
9. Complete nutrient budget for nitrogen, phosphorus, and potassium for the rotation or crop sequence.

If increases in soil phosphorus levels are expected, plans shall document:

- The soil phosphorus levels at which it may be desirable to convert to phosphorus based implementation.
- The phosphorus soil sorption ability may be reduced by heavy application of manure and that may limit the future phosphorus application rate.
- The relationship between soil phosphorus levels and potential for phosphorus transport from the field.
- The potential for soil phosphorus drawdown from the production and harvesting of crops.

When applicable, plans shall include other practices or management activities as determined by specific regulations, program requirements, or producer goals.

In addition to the requirements described above, plans for nutrient management shall also include:

- Discussion about the relationship between nitrogen and phosphorus transport and

water quality impairment. The discussion about nitrogen should include information about nitrogen leaching into shallow ground water and potential health impacts. The discussion about phosphorus should include information about phosphorus accumulation in the soil, the increased potential for phosphorus transport in soluble form, and the types of water quality impairment that could result from phosphorus movement into surface water bodies.

- Discussion about how the plan is intended to prevent the nutrients (nitrogen and phosphorus) supplied for production purposes from contributing to water quality impairment.

- A statement that the plan was developed based on the requirements of the current standard and any applicable federal, state, or local regulations or policies; and that changes in any of these requirements may necessitate a revision of the plan.

OPERATION AND MAINTENANCE

Review of Nutrient Management Plan

The owner/client is responsible for safe operation and maintenance of this practice including all equipment.

Operation and maintenance addresses the following:

- NMP shall be reviewed to determine if adjustments or modifications to the plan are needed.
- Documentation of the actual rate at which nutrients were applied. When the actual rates used differ from or exceed the recommended and planned rates, records will indicate the reasons for the differences.
- NMP might be reviewed if one or more of the following conditions occurs:
    1. Change in landowner or operator.
    2. Increase in livestock.
    3. Major changes or substitution of waste handling and storage system.
    4. Increase or decrease of application area.
    5. Change in application system.
    6. New designation as a sensitive area.
    7. Change in crop or crop rotation.

Safety

- Protect fertilizer and organic by-product storage facilities from weather and accidental leakage or spillage.
- Workers should be protected from and avoid unnecessary contact with chemical fertilizers and organic by-products. Protection should include the use of protective clothing when working with plant nutrients. Extra caution must be taken when handling ammonia sources of nutrients, or when dealing with organic wastes stored in unventilated enclosures.
- The disposal of material generated by the cleaning nutrient application equipment should be accomplished properly. Excess material should be collected and stored or field applied in an appropriate manner. Excess material should not be applied on areas of high potential risk for runoff and leaching.
- The disposal or recycling of nutrient containers should be done according to state and local guidelines or regulations.

Equipment

- Equipment shall be cleaned after application. Wastewater resulting from flushing application should be disposed away from any sensitive zones.
- Equipment used for application shall be calibrated to ensure uniform distribution of material at planned rates.
- Special precautions must be taken to avoid well contamination when using fertigation.

Field Record

- The producer shall maintain field level record for a minimum of five years. As applicable, records include:

1. Soil, plant tissue or manure test results and recommendations for nutrient application.
2. Quantities, analyses and sources of nutrients applied.
3. Dates and method of nutrient applications.
4. Crops planted, planting and harvest dates, yields, and crop residues removed.
5. Dates of review and person performing the review, and recommendations that resulted from the review.

Table 1: Crop uptake and general nutrient recommendations for crops grown in the Caribbean Area										
Crop	Crop uptake				Nutrient recommendation[1]					
	N	P	K	Yield (Fresh weight)	N	P	K	Other	Average Yield (Fresh weight)	Comments
	lbs./acre/year				lbs./acre/year					
Horticultural										
Tomatoes[2]	180	21	280		155	41, 67	66		35000	N applied via drip irrigation. Apply low P or high P levels if soil test P is in high or lower soil test categories, respectively. Apply K level if soil level is in medium or lower test categories.
					103					Apply this N amount pre-plant, and sidedress at flowering.
Peppers[2]	140	12	140		155	41, 67	25,30		25000	N applied via drip irrigation. Apply low P and K or high P and K levels if soil test is in high or lower soil test categories, respectively.
					103					Apply this N amount pre-plant, and sidedress at flowering.
Cucumber	45	36	71	26710	155, 206	23	43		24750	N: Apply this amount by fertigation. Apply low or high N levels if soil total N test is in high or lower test categories, respectively. 50 lbs. of N can be applied pre-plant. P and K, apply this amount pre-plant if soil test P and K are medium or low.

Crop	Crop uptake				Nutrient recommendation					
	N	P	K	Yield (Fresh weight)	N	P	K	Other	Average Yield (Fresh weight)	Comments
	lbs./acre/year				lbs./acre/year					
EGGPLANT					103	21, 103	21, 129		25000	Apply this N amount pre-plant, and sidedress at flowering. Apply low P and K or high P and K levels if soil test P and K are in high or lower test categories, respectively.
Sweet Pepper					103	44	68		8750	Apply this amount split in 6 applications via drip irrigation at 2-week intervals.
					50	22	33			Apply this amount as pre-plant. Not fertigated field applies this amount as sidedress at flowering and harvesting.
Beans[3]	90	16	179	890	21-31	0-4; 9-13; 15-25	0-18; 30-47; 64-94		2100	N: apply this amount pre-plant and at flowering. P and K: Apply these amounts when P and K levels are in the high, medium, and low categories, respectively.
Coffee[4]	228	17	205	2000					2000	
Coffee year					91 - 137	39 - 59	38 - 57	17 - 25 Mg		Total amount split into 4 applications using complete fertilizer mixture when soils is in low N, P, and K categories. High density (1815 pl./acre).
Coffee year 1					56 - 82	24 - 35	23 - 34	10 - 14 Mg		Total amount split into 4 applications using complete fertilizer mixture when soils is in low N, P, and K categories. Low density (1089 pl./acre).

Crop	Crop uptake				Nutrient recommendation					
	N	P	K	Yield (Fresh weight)	N	P	K	Other	Average Yield (Fresh weight)	Comments
	lbs./acre/year				lbs./acre/year					
Coffee year 2					182 - 228	78 - 98	121 - 149	33-41 Mg		Total amount split into 4 applications using complete fertilizer mixture when soils is in low N, P, and K categories. High density (1815 pl./acre).
COFFEE YEAR 2					109 - 137	47 - 59	73 - 91	20-25 Mg		Total amount split into 4 applications using complete fertilizer mixture when soils is in low N, P, and K categories. Low density (1089 pl./acre).
Coffee year 3					307 - 409	44 - 59	254 - 336	37-49 Mg		Total amount split into 3 applications using complete fertilizer mixture when soils is in low N, P, and K categories. High density (1815 pl./acre).
Coffee year 3					184 - 245	27 - 35	154 - 204	23-30 Mg		Total amount split into 3 applications using complete fertilizer mixture when soils is in low N, P, and K categories. Low density (1089 pl./acre)
Coffee year 4					409 - 819	59 - 117	336 - 680	47-98 Mg		Total amount split into 3 applications using complete fertilizer mixture when soils is in low N, P, and K categories. High density (1815 pl./acre).
Coffee year 4					245 - 491	35 - 70	204 – 408	30-59 Mg		Total amount split into 3 applications using complete fertilizer mixture when soils is in low N, P, and K categories. Low density (1089 pl./acre).
Cabbage	90	13	100	30000[5]	103-155	43	66		35000	Split apply this amount (post-plant and during head cabbage formation) if soil N level is under high test category. Apply P and K amount if soils test level is not in high categories.
	268	27	205	62000[4]						
Pigeon Peas										Crop does not respond to fertilizer application in most fertile soils.

Crop	Crop uptake				Nutrient recommendation					
	N	P	K	Yield (Fresh weight)	N	P	K	Other	Average Yield (Fresh weight)	Comments
	lbs./acre/year				lbs./acre/year					
Watermelon	40	5	54	10000[5]	88-103	24, 44, 67	85, 129, 171		24000	N: Split apply this amount pre-plant, and 1 month after transplanting. N, P and K: apply this amount when soil test is in high, medium or low category, respectively.
	64	9	96	16000[4]						
Pumkin[5]	96	11	93	24000	103 - 155	44	66		24000	Apply this N amount pre-plant, and during the first 1.5 months after transplant. Apply P and K amounts if soil test P and K are in the low category.
Sweet Corn[2]	155	20	105	8000						
Lettuce[2]	107	13	191	36000						
Onion					155, 206	23	43		24750	N: Apply this amount by fertigation; Apply low or high N levels if soil total N test is in high or lower test categories, respectively. 50 lbs. of N can be applied pre-plant. P and K, apply this amount pre-plant.

Crop	Crop uptake				Nutrient recommendation					
	N	P	K	Yield (Fresh weight)	N	P	K	Other	Average Yield (Fresh weight)	Comments
	lbs./acre/year				lbs./acre/year					
Fruits										
Mango[6]	93	11	88	14256						
Mango 6 months					3-7	1-2	2-4			Apply low and high level amount in low (41 pl./acre) and high density (109 pl./acre), respectively.
Mango year 1					13-20	3-4	9-14			Apply low level early in the year and high level six months later. High density (109 pl./acre).
Mango year 1					5-7	1-2	3-5			Apply low level early in the year and high level six months later. Low density (41 pl./acre).
Mango year 2					26-33	6-7	18-23			Apply low level early in the year and high level six months later. High density (109 pl./acre).
Mango year 2					10-12	2-3	7-9			Apply low level early in the year and high level six months later. Low density (41 pl./acre).

Crop	Crop uptake				Nutrient recommendation					
	N	P	K	Yield (Fresh weight)	N	P	K	Other	Average Yield (Fresh weight)	Comments
	lbs./acre/year				lbs./acre/year					
MANGO YEAR 3					39-46	9-10	27-32			Apply low level early in the year and high level six months later. High density (109 pl./acre).
Mango year 3					15-17	3-4	10-12			Apply low level early in the year and high level six months later. Low density (41 pl./acre).
Mango year 4					52-59	12-13	36-41			Apply low level early in the year and high level six months later. High density (109 pl./acre).
Mango year 4					20-22	4-5	14-15			Apply low level early in the year and high level six months later early. Low density (41 pl./acre).
Mango year 5					65-72	15-16	45-50			Apply low level early in the year and high level six months later. High density (109 pl./acre).
Mango year 5					25-27	5-6	17-18			Apply low level early in the year and high level six months later. Low density (41 pl./acre).
Mango + 8 years					25-75	5-15	17-51			Total amount applies using a complete fertilizer mixture. High density (109 pl./acre). Amount level applies increases with production.

Crop	Crop uptake				Nutrient recommendation					
	N	P	P	Yield (Fresh weight)	N	P	K	Other	Average Yield (Fresh weight)	Comments
	lbs./acre/year				lbs./acre/year					
Mango + 8 years					65-195	15-45	45-135			Total amount applies using a complete fertilizer mixture. Low density (41 pl./acre). Amount level applies increases with production.
PAPAYA[7]	156	18	187	80000	23	10	19		121,500	Apply this amount after transplant.
					34,45,56	15,19,24	28,37,46			Apply this amount 1, 2 and 3 months after transplant, respectively.
					90	39	75			Apply monthly this amount from 4 - 14 months after transplant.
ORANGES[8]	38	4	56	48000 var. Valencia						
Citrus year 1					34-19	15-8	23-12			Total amount split into 3 applications using complete fertilizer mixture. Apply high and low level to high density (222 pl./acre) and low density (121-pl./acre) density, respectively.
Citrus year 2-3					103-56	18-10	57-31			Total amount split into 2 applications using complete fertilizer mixture. Apply high and low level to high density (222 pl./acre) and low density (121-pl./acre) density, respectively.
Citrus year 4					206-274	35-47	114-152			Total amount split into 2 applications using complete fertilizer mixture. High density (222 pl./acre).

Crop	Crop uptake				Nutrient recommendation					
	N	P	K	Yield (Fresh weight)	N	P	K	Other	Average Yield (Fresh weight)	Comments
	lbs./acre/year				lbs./acre/year					
Citrus year 4					112-150	19-26	62-83			Total amount split into 2 applications using complete fertilizer mixture. Low density (121 pl./acre).
Citrus year 5					229-343	49-59	190-380			Total amount split into 2 applications using complete fertilizer mixture. High density (222 pl./acre).
Citrus year 5					125-187	27-32	103-207			Total amount split into 2 applications using complete fertilizer mixture. Low density (121 pl./acre).
Citrus year 6					274-412	59-71	228-456			Total amount applies using a complete fertilizer mixture. High density (222 pl./acre).
Citrus year 6					150-224	32-38	124-248			Total amount split into 2 applications using complete fertilizer mixture. Low density (121 pl/acre)
Citrus year 7					320-481	69-83	266-532			Total amount applies using a complete fertilizer mixture. High density (222 pl./acre).
Citrus year 7					175-261	37-44	145-290			Total amount split into 2 applications using complete fertilizer mixture. Low density (121 pl/acre).
Citrus year 8					366-553	79-95	303-607			Total amount applies using a complete fertilizer mixture. High density (222 pl./acre).
Citrus year 8					200-299	43-51	166-331			Total amount split into 2 applications using complete fertilizer mixture. Low density (121 pl./acre).

Crop	Crop uptake				Nutrient recommendation					
	N	P	K	Yield (Fresh weight)	N	P	K	Other	Average Yield (Fresh weight)	Comments
	lbs./acre/year				lbs./acre/year					
Citrus year 9					412-662	89-106	342-683			Total amount applies using a complete fertilizer mixture. High density (222 pl./acre).
Citrus year 9					225-335	48-58	186-372			Total amount split into 2 applications using complete fertilizer mixture. Low density (121 pl./acre).
Citrus year 10					457-731 (572-858)	98-118 (123-147)	380-759 (475-949)			Total amount applies using a complete fertilizer mixture. High density (222 pl./acre). Maximum level amounts reached after 10 years are in parenthesis.
Citrus year 10					249-374 (312-467)	54-64 (67-80)	207-413 259-517)			Total amount split into 2 applications using complete fertilizer mixture. Low density (121 pl./acre). Maximum levels amount reached after 10 years are in parenthesis.
Pineapple[9]	182	22	290	49005	300-399 (173)	21-32 (50)	207-248 (144)		48000	These nutrients are provided from complete fertilizer mixture recommended. Total amount split into 3 applications (1-2 months, 4-5 months and 8-9 months post-plant). The Land Authority producers in the north part of Puerto Rico use N, P, and K levels in parenthesis.
Avocado[10]	36	9	44	28800						

Crop	Crop uptake				Nutrient recommendation					
	N	P	K	Yield (Fresh weight)	N	P	K	Other	Average Yield (Fresh weight)	Comments
	lbs./acre/year				lbs./acre/year					
Avocado year 1					13-9	3-2	7-5			Total amount split into 3 applications using a complete fertilizer mixture. Apply high and low level to high (70 pl./acre) and low (48 pl./acre) density, respectively.
Avocado year 2					17-25	4-6	9-14			Total amount split into 2 applications using a complete fertilizer mixture. High density (70 pl./acre).
Avocado year 2					12-17	2-4	6-10			Total amount split into 2 applications using a complete fertilizer mixture. Low density (48 pl./acre).
Avocado year 3					21-42	5-9	35-70			Total amount split into 2 applications using a complete fertilizer mixture. High density (70 pl./acre).
Avocado year 3					19-29	4-6	32-48			Total amount split into 2 applications using a complete fertilizer mixture. Low density (48 pl./acre).
Avocado year 4					42-56	9-12	70-93			Total amount split into 2 applications using a complete fertilizer mixture. High density (70 pl./acre).
Avocado year 4					29-38	6-8	48-64			Total amount split into 2 applications using a complete fertilizer mixture. Low density (48 pl./acre).
Avocado year 5					56-70	12-15	93-116			Total amount split into 2 applications using a complete fertilizer mixture. High density (70 pl./acre).

Crop	Crop uptake				Nutrient recommendation					
	N	P	K	Yield (Fresh weight)	N	P	K	Other	Average Yield (Fresh weight)	Comments
	lbs./acre/year				lbs./acre/year					
Avocado year 5					38-48	8-10	64-80			Total amount split into 2 applications using a complete fertilizer mixture. Low density (48 pl./acre)
Avocado year 6					84-140	18-30	193-232			Total amount split into 2 applications using a complete fertilizer mixture. High density (70 pl./acre).
Avocado year 6					58-96	12-21	95-156			Total amount split into 2 applications using a complete fertilizer mixture. Low density (48 pl./acre).
Avocado + 10 years					140	30	232			Total amount split into 2 applications using a complete fertilizer mixture. High density (70 pl./acre).
Avocado + 10 years					96	21	156			Total amount split into 2 applications using a complete fertilizer mixture. Low density (48 pl./acre)
Agronomic										
Sorghum[4] (grain)	247	39	164	8000						
TOBACCO[4]	125	11	211	3000						
Rice[11]	110	22	116	5000	120	11	54		5000	Total amount split into two applications in soils with N, P and K low test categories.

Crop	Crop uptake				Nutrient recommendation					
	N	P	K	Yield (Fresh weight)	N	P	K	other	Average Yield (Fresh weight)	Comments
	lbs./acre/year				lbs./acre/year					
Sugarcane	105	23	185[12]		185-120	77-20	216-50			New seedlings; apply low or high levels if soil test are in high or lower test categories, respectively.
	75	22	149[5]	100000	124 -144	0-66	0 –171			Suckers; apply low or high levels if soil test are in high or lower test categories, respectively.
Grass [13]				(Dry matter)						
GUINEA	288	44	362	22962	330-300	48-44	189-171			These nutrients are provided from complete fertilizer mixture recommended. Total amount split into 4 applications. Apply high level to hay green shop and low level to forage grazing. N, P, and K level are for low soil test categories. N level applies in hay and green shop may increase up to 600 lb./acre and P level up to 60 lb./acre.
Napier	301	64	502	25908						
Pangola	298	47	356	23585						
Malojillo	306	43	382	23941						
CONGO	304	49	401	29815						
Star	345	58	418	25187						
Sorghum[4]	196	29	235	14400						
Farinaceous										
Plantains[14]	215	19	521		288	25	598	52 Mg		These nutrients are provided from complete fertilizer mixture recommended. Split this amount into four applications in soils with N, P and K low-test categories.

Crop	Crop uptake				Nutrient recommendation					
	N	P	K	Yield (Fresh weight)	N	P	K	other	Average Yield (Fresh weight)	Comments
	lbs./acre/year				lbs./acre/year					
Bananas[14]	247	20	633		264-432	19-31	548-896	52 Mg	26000-52000	These nutrients are provided from complete fertilizer mixture recommended. Split this amount into four applications in soils with N, P and K low-test categories. Apply low N, P and K levels in low-density 721 pl./acre) and the high levels in high density (906 pl./acre).
Yam	169	22	191	45924[15] var. Florido	147-218	63-94	198-294		20000	These nutrients are provided from a complete fertilizer mixture recommended. Apply this amount in soils with N, P and K low-test categories, one month after seed sprout. Apply low N, P and K levels in low density (7260 pl./acre) and the high levels in high density (10890 pl./acre).
	105	106	142	28256[16] var. Florido						
	190	17	199	52300[17] var. Guinea						
Cassava[18]	182	5	164	19808	30-40	13-17	50-66		30000	These nutrients are provided from a complete fertilizer mixture recommended. Split total amount in two applications (first and third month after after planted) in soils with N, P and K low test categories. Apply low N, P and K levels in low density (2723 pl./acre) and the high levels in high density (4840 pl./acre).

Crop	Crop uptake				Nutrient recommendation					
	N	P	K	Yield (Fresh weight)	N	P	K	other	Average Yield (Fresh weight)	Comments
	lbs./acre/year				lbs./acre/year					
Tanier	273	74	371	20827[19] var. Blanca	88-138	19-30	110-171	16-25	8000	These nutrients are provided from a complete fertilizer mixture recommended. Apply this amount in soils with N, P and K low-test categories. Apply low N, P and K levels in low density (7000 pl./acre) and the high levels in high density (11000 pl./acre).
	129	36	196	10071[19] var. Kelly						
	111	13	139	var. Morada						
Sweet Potato					48-60	21-26	80-100		25000	These nutrients are provided from a complete fertilizer mixture recommended. Apply this amount in soils with N, P and K low-test categories.
Caladium (Malanga)					80	34	108		16000	These nutrients are provided from a complete fertilizer mixture recommended. Apply this amount in soils with N, P and K low-test categories.

SOURCES

[1] Data summarized from “Conjuntos Tecnológicos”, University of Puerto Rico, Agricultural Experiment Station by Agronomist José A. Castro, USDA, NRCS and Dr. David Sotomayor, College of Agricultural Science, UPR, Mayagüez Campus.

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